INTRA-LABORATORY CORRESPONDENCE

OAK RIDGE NATIONAL LABORATORY

December 3, 1958

To: C. J. Borkowski
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M. E. Ramsey [redacted]
C. E. Winters
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Subject: Information for Review of Graphite Reactor Operation

The operation of the Graphite Reactor was quite uneventful in 1958. A number of developments are underway or pending primarily in annealing and reloading. These are listed briefly here and we shall be glad to discuss them in the December 5 meeting.

Annealing the Graphite Reactor

The stored energy of the graphite has been measured, and the region having energy above the specific heat curve has been blocked out. The rate of release of stored energy versus temperature is known for adiabatic conditions. Differences in the oxidation rate of the irradiated and nonirradiated graphite have been studied. Some slight increases in the oxidation rate have been found in the irradiated graphite removed from the reactor. Contour measurements across the top of the graphite stack show that the maximum growth of the graphite is about 3/8-inch.

Among the methods of releasing stored energy which have been studied are the following:

1. Recirculating, externally heated, air system.
2. Single-pass hot air systems utilizing heaters placed in a by-pass air duct system.
3. Single-pass externally heated system for injecting hot air into the fuel channels via the fuel loading holes.
4. Nuclear heat using an enriched uranium alloy fuel element loading (already proposed) which would permit higher temperature operation.
5. Nuclear heat using the present (or enriched loading) but incorporating a ducting system for reversing the cooling air flow and thus the temperature distribution.

Items 1 and 2, above, were essentially eliminated by consideration of safe temperature limits for the concrete ducting and main shielding walls.

Item 4 depends, first, upon the decision to proceed with the enriched loading. Furthermore, there is some doubt that the required temperature distribution could be obtained in this manner.

Feasibility testing has been done on item 3 with various degrees of success. The results indicate that such a system may be used successfully if applied on a rather large scale. The following undesirable qualities are inherent in this system:

1. Large, expensive, external equipment set-up.
2. Complex vacuum system for vacuum-jacketed air injection tubes to prevent overheating of the front face shielding wall.
3. Long runs of bulky insulated piping or ducting for supplying the hot air.
4. Long reactor shut-downs to permit installation of equipment and performance of the annealing operation.
5. Repetition of operation several times in order to cover the entire region of graphite containing negative specific heat.

Item 5 is now under study. It presents the following main problems:

1. Stored energy in the radial fringe zones may be difficult to remove without orificing channels to raise temperatures.
2. The loading face shielding wall will be subject to a larger pressure force and must be investigated for structural strength.
3. The cooling air will exit against the loading face wall which has no thermal shield and thus may be subject to excessive temperatures.
4. A ducting system must be installed to permit reversal of the coolant flow.
5. The graphite structure will be subject to a reversal of pressure force and thus structural shifts are possible.

Engineering presently has a work order to investigate these effects and to prepare a comparative cost estimate for the systems under items 3 and 5 of this section. Preliminary estimates of $150,000 and $38,000, respectively, have been obtained.

In order to complete the evaluation of the different methods, the following information is being obtained.

1. Stored energy release as a function of time at constant temperature.
2. Graphite temperature distribution under normal reactor operating conditions.
3. Estimate of stored energy condition in the reactor after the performance of various types of annealing operations which produce stipulated temperature distributions.
4. The temperature distribution and/or time conditions necessary to remove all of the stored energy above the graphite specific heat curves

Reloading with Enriched Fuel

A safeguard report was completed last summer but a decision on the reloading has been deferred pending a review of experience at BNL. This is now being done by the Solid State Division. Preliminary bids were received on 5000 fuel elements. Work has been completed on a method of decreasing the release time of the safety rods.

Remote Operation

Remote operation of the graphite reactor is being investigated by the Reactor Controls group. It is now proposed to rebuild the controls before transferring the controls to the ORR.

Additional Vertical Holes

Because of the demand for vertical experimental holes, some engineering is being done on the feasibility of drilling additional vertical holes approximately 4" in diameter.

Utilization

The following general operating data is for the first half of 195[illegible]:

Total energy, Mwd	559.9
Average power, kw/operating hour	3,477
Time operating, %	[illegible]
Slugs charged, 4-in. bonded	[illegible]
Slugs discharged, 4-in. bonded	961
Research samples	755
Radioisotope samples	1,175
Slugs charged, 3-in. bonded	497
Slugs discharged, 3-in. bonded	447

Reactor Controls

During the year the Graphite Reactor Controls have been "cleaned up." The wiring was largely redone, and the 24-V circuits were replaced with 110-V systems.

Canal

Radiation levels in the canal work area remain unchanged at about 30 - 40 mr/hr. Most of the radiation exposure for Reactor Operations Department personnel is incurred doing work in the canal. This exposure could be reduced considerably by adding 18 inches to the canal depth and by building a good demineralizer system that would recirculate canal water.

Filter House

Pa^{233} contamination of the filter house and fans of the Graphite Reactor occurred just prior to the last meeting. Decay continued without any further addition of activity. By December 30, 1957, the radiation reading of the No. 2 fan housing was normal, 0.7 mr/hr. On November 4, 1957, the reading at this same spot was 7.0 mr/hr.

Fan House

On July 1, 1958, the No. 3 compressor bearing temperatures started increasing, and the fans and reactor were manually shut down. An immediate check in No. 3 fan cell disclosed an oil fire at the bearings. The increase in temperature would have shut down the fan and the reactor automatically if it had been allowed to continue.

Both bearings were severely wiped and had to be replaced.

On checking the malfunction of the shaft pump, a rubber stopper was found in its suction port. The rubber stopper was left in the oil line after the inspection of the bearings on June 30, 1958. The stopper was placed in the line at this time to prevent oil from running out on the floor from the reservoir.

It is believed that the auxiliary pump overheated and cut off due to thermal overload; however, the compressor shutdown pressuretrol did not shut the fan down because air, sucked into the oil lines by the shaft pump, was in the oil line to the pressuretrol. These pressuretrols are being relocated to obviate the possibility of air causing trouble in the future.

The reactor operated at half power from the time the fan shut down on July 1, 1958, until 10:20 p.m. on July 4, 1958, at which time the bearings replacement job was finished (including realignment of compressor and motor).

Fuel Usage

During the eleven months between November 1957 and October 1958, an average of 83 slugs were used per month. The supply at the beginning of October was 1926 bonded 4-inch slugs. Slug usage in the past has usually been much higher, but it has been possible to leave about 16 channels empty as they were discharged. This is because the Pu growth has resulted in an increase in reactivity.

A group of 100 four-inch Hanford slugs have been ordered. These will be tested with Savannah River slugs to decide if some usable combination of the two can be loaded into the Graphite Reactor in place of bonded "X" slugs.

An attempt is also being made to obtain some slightly enriched oxide slugs for test.

Radiation Incident

During August it was necessary to evacuate the first level, south, of Building 3001 for several hours when a leak developed in the CO_2 system of the pneumatic tube. Nasal smears up to 393 c/m were found. Overnight urine samples from all persons involved indicated an insignificant internal dose. The CO_2 leak has been repaired.

X-847

INTRA-LABORATORY CORRESPONDENCE

OAK RIDGE NATIONAL LABORATORY

Novmeber 6, 1959

To: M. E. Ramsey, C. J. Borkowski, E. P. Epler, F. W. Manning, R. H. Ritchie, C. E. Winters, E. O. Wollan, F. Kertesz

Subject: Information for Review of Graphite Reactor Operation

The past year has been marked by improvements in the canal, by several new vertical experiment holes drilled in the top of the reactor, and by completion of annealing plans. The reactor operated approximately 90% of the time and no major troubles were experienced.

Annealing

A safeguard report, ORNL 2725, was submitted to the AEC on April 21, 1959; and approval was received on September 9. Since then, work has begun on the alterations necessary for the annealing. Most of the work is associated with the installation of ducts necessary for reversal of air flow through the reactor. Also a considerable amount of instrumentation is being added for monitoring temperatures in the reactor, for measurement of air flow, and for monitoring the exit air flow for possible radioactivity release.

Most of the instruments for graphite and fuel element temperature measurements have been obtained and are being installed. A master patch panel, for use in connecting thermocouples to appropriate monitoring instruments, has been purchased and is ready for installation. Installation of the conduit and thermocouple lead wire between the reactor fuel-loading face and the control room is essentially complete.

A moving-tape instrument, for continuous monitoring of the exit-air particulate radioactivity, has been received and will be placed in operation soon. Several months of operational data may be required to establish the response characteristics of the instrument under conditions of normal reactor operation and fuel element cladding failure.

The following revisions of, and additions to, the OGR instrumentation are required for safety and control of the reactor during the annealing operation.

Air Flow Measurements

Inlet air	Pitot tube to be installed in the new sheet-metal duct; monitored in control room.	Pitot tube and monitor to be purchased and installed.
Exit air	Pilot venturi to be installed in exit-air duct near fan house.	Pitot tube and monitor to be purchased and installed.
By-pass damper control	Air operated damper control to be operated from control room.	Damper and controls to by purchased and installed by CPFF.
Limiting orifice	Variable area orifice, to be calibrated for flow measurement and monitored in control room.	To be fabricated and installed by CPFF; instruments by ORNL.
East air manifold pressure	Pressure tap into east manifold, recorded in control room; fan shut-off and scram to limit negative pressure.	Equipment to be purchased and/or fabricated and installed.
Differential pressure across the reactor	Reversing valve arrangement for the present ΔP monitors.	To be added.
Reactor period limits	Revision of period monitor and the rod controls to provide reverse and scram limits.	Work completed.

Temperature Measurements

Graphite temperature thermocouples	~160 thermocouples to be installed in fuel channels.	~50 installed; the remainder will be installed a few weeks prior to the annealing.
Fuel element	A minimum of 40 to be installed on fuel slugs 2 feet east of the reactor center line.	6 installed; the remainder to be installed a few weeks prior to the annealing.

Concrete temperature thermocouples	~15 to be installed in wells to be drilled in the front face shield wall.	To be installed a few weeks prior to the annealing.
Temperature indicating and recording instruments	7 recorders (12 point), 3 indicators (48 point); located in control room.	Instruments are on hand, they have been checked out and are being installed.
Radioactivity Monitors		
Exit-air gaseous fission-product activity	Charcoal trap monitored by a G.M. tube or ionization chamber.	To be fabricated and installed; electronics to be purchased.
Exit-air particulate radioactivity monitor*	Probe for use in new exit-air duct.	To be fabricated and installed.
Exit-air particulate radioactivity monitor	Moving-tape monitor (continuous recording of exit-air particulate activity).	On hand and ready for installation.

*This device may be deemed unnecessary if the moving-tape monitor produces the expected results.

Limits for permissible levels of gaseous activity have not been established, and this makes it difficult to set the safety devices for the annealing experiment at the proper point. The same problem makes it difficult to evaluate experiment hazards and normal operating levels of radioactivity in the stacks. It is hoped that the permissible levels may be established soon in a manner easy to interpret for operation.

Fuel

A year ago, there appeared to be some danger of running out of fuel slugs for the reactor. It was found, however, that 1.1-inch diameter hollow slugs 8 inches long, known as "dingot" slugs, could be obtained from the Savannah River reactors. Although insufficient data have been obtained to be conclusive, preliminary measurements indicate that little change in reactor excess reactivity is to be expected upon replacement of OGR bonded fuel slugs with "dingot" slugs.

Temperature data are being gathered on these slugs to insure that they will be safe if the center hole should become plugged. This might result in excessively high temperatures at the aluminum-uranium interface. No such trouble has been experienced to date in operation.

A supply of 5000 of the dingot fuel elements is now on hand, along with 1153 old bonded slugs. The old slugs will be used, when needed, in experiments necessary in comparing the performance of the two types.

There are now 37 empty fuel channels. This is an increase of 10 in the last three months. During this time, the reactivity of the reactor has remained stable between 100 and 130 inhours. A gain in reactivity from the build up of plutonium, together with cooler temperatures, is largely responsible.

Slug ruptures have continued at approximately the same rate of previous years. There have been 22 so far in 1959 compared with 20 in 1958 and 41 in 1957. Due to the tested methods of handling ruptures, none have caused a major contamination problem except in the canal where it is necessary to purge large quantities of water to the process drain to reduce the contamination.

Vertical Holes

Two holes 3-in. and 3 7/8-in. diameter have been drilled through the shield into the graphite to depths of 13 ft 4 in. and 15 ft, respectively. The holes will satisfy a request of the Solid State low temperature group for hole 10 which is now being used for short-term irradiations by the isotopes and activation analysis groups. The irradiation facility will be moved to one of the new holes, leaving hole 10 for Solid State. The experience gained in drilling vertically through seven feet of concrete and 15 feet of graphite with only approximately 1/4-in. deviation from vertical should make it possible to provide more holes for experimenters or control rods if needed.

Canal

As reported last year, the canal was the major source of personnel radiation exposure. It was often necessary to work several hours at a time in radiation fields of 40 mr/hr in the canal where large amounts of fuel are stored pending processing in the Hot Pilot Plant. To reduce this radiation, which largely came from the highly contaminated concrete near the water-level line, the walls were raised 18 in. Stainless steel was used to line the water side of the raised portion of the wall so that the new water-level line would not become radioactive. The increased depth of water effectively shielded the old water line and the radiation was reduced to about 1/10 of its former value.

Contamination in the canal water from corroded slugs or from ruptures discharged from the reactor is still a problem. Whenever a rupture occurs, it is necessary to pump large quantities of water (~200 gpm) to the process waste system to reduce the radioactivity. It is usually necessary to pump similar quantities from the canal each week so that the deep pit will be clean enough for shutdown work. Large quantities of water must also be "purged" from time to time to clean the floors of thick layers of silt which collect there. A demineralizer recycling about 50 gpm of the water in the canal together with sand filters through which 100-150 gpm could be recycled would eliminate most of the contamination in the water and the release of radioactivity to the process waste system. Several pieces of this equipment are available and if sufficient funds can be obtained for installation a considerable improvement in operations could be effected.

Remote Operation

Until some advantage can be seen in combining the Graphite Reactor-LITR with the ORR controls in one control room, the present arrangement will be continued. It appears that one operator probably could not operate three control panels without help so that there would be no saving in manpower.

Facility Utilization

The unassigned holes are as follows: 3, 11, 13, 18, 21, 54N, 55N, 56N, 57S, 58N, C, 1768, east animal tunnel, and slant animal tunnel. This is a total of 14 unassigned facilities. At the end of December 1958 the following facilities were unassigned: 16N, 17S, 54N, 55N, 57S, 58N, 59S, east animal tunnel, and slant animal tunnel, or a total of 9.

The change was brought about by the Isotopes Division's release of holes 3, 13, 18, and 21. Holes 3 and 21 had been used for years for production of P^{32} from sulfur. This is now accomplished more efficiently at the LITR and ORR. Hole 13 has been used for standard isotope irradiations. The market for this item has declined as was expected. Hole 18 was used for Sb-Be neutron source production but is being given up. The Chemical Technology Division is also giving up Hole 11.

By the first of 1960, it is planned to stop irradiation of natural uranium in the OGR for iodine-131 production.

Radiation Incident

Two radiation incidents occurred at the Graphite Reactor pneumatic tube when gas leaked from the pneumatic-tube system into the laboratory at the first level, south. No one was overexposed in either instance. The air activity reached tolerance and personnel, alerted by CAM alarm, quickly evacuated. The room was evacuated approximately 16 hours for one incident while the room was decontaminated. The other evacuation lasted only a few hours. It was found to be impossible to stop the leaks without rebuilding the system so an enclosure connected to the pile vacuum was built around the vulnerable portions of the system. Leakage of gaseous activity is now safely vented to the pile cooling system.

Fan House

Due to trouble resulting from air locks in the oil systems of the #2 and #3 fans, the pressure trols were moved from the north wall instrument panel and relocated by the oil reservoir and horizontal to the pressure take-off points. This has made the safety system on the fans much less susceptible to failure.

Reactor Controls

The "cleanup" of the Graphite Reactor control system, begun last year, was completed along with a number of improvements which are described below. New drawings have been made showing all changes, and they have been checked against the installation itself.

The automatic PAT control unit has been replaced by an ORNL servo amplifier. Removal of the PAT recorder from the servo loop has improved the operation of the servo system. The reactor may be placed under automatic control whenever the #5 horizontal rod is within servo range; that is, between 48 inches out and 217 inches out. The control will revert to manual in case of a scram or on request by the operator.

The Log N period recorder has been arranged to scram the reactor at periods less than 5 seconds and to give a reverse at periods less than ten seconds. The count rate period recorder will give a reverse of all four horizontal rods at periods less than ten seconds. Insertion will cease as soon as the short period has been corrected. Two new functions have been added to the servo power recorder. An alarm at 110% and a reverse at 120% of full power are provided.

Preliminary design work was completed for improvements to the safety rods. The present release time is of the order of $\sim 1/2$ sec; whereas, it has been determined that release times of 40-50 ms may be achieved by improving the clutch and release circuits. The cost for three rods would probably be about $10,000. Since the proposal to use enriched fuel has been dropped, there appears to be no pressing need to improve the present safety system.

One of the most pressing needs is for an instrument engineer who could devote full time to the reactors. Since our safety systems are the one-out-of-two type, any instrument failure generally shuts down the reactor. Other laboratories have designed two-out-of-three systems for the reactors and experiments. We have not adopted such a system because of the increased cost, decreased safety, and necessity of monitoring each of the channels frequently. Great improvements have been effected in design of experiment instrumentation by standardizing designs and by use of approved components. This has improved the reliability of experiment instrumentation tremendously. We need, however, an instrument engineer who can devote full time to maintenance of instruments, both reactor and experiment, to improve reliability and decrease the number of false scrams.

General Operating Data--January through September, 1959

Total energy, Mwd	837.0
Ruptured fuel elements	22
Average power, kw/operating hours	3,425
Time operating, %	89.5

Slugs charged, 4" bonded	588.0
Slugs charged, 8" SAR	676
Slugs charged, 8" dingots	49
Slugs discharged, 4" bonded	1,495
Slugs discharged, 8" SAR	630
Research samples	832
Isotopes samples	905

Personnel Exposure

Using 5 rem as the MPD/yr and a weekly exposure rate of 0.1 rem/wk, the permissible dose through October 1, 1959, for the current year, would be 39 x 1 = 3.9 rem.

Listed below are the percentages of the MPD accumulated through October 1, 1959, for the current year. Operators and foremen (24 people) are considered.

	Average	High	Low
TSR_c (1)	19.7% 0.76 rem	30.0% 1.20 rem	8.0% 0.33 rem
D_m (2)	20.0% 1.56 rem	29.0% 2.29 rem	10.1% 0.795 rem
D_l (3)	35.0% 1.39 rem	52.0% 2.06 rem	17.0% 0.69 rem
D_p (4)	35.0% 1.39 rem	52.0% 2.06 rem	17.0% 0.69 rem

(1) Weekly dose is assumed to be twice the dose shown by pocket meters.

(2) Moderately penetrating dose (MPD for skin exposure corresponding to tissue depth of 7. mg/cm^2 is twice the MPD for penetrating radiation).

(3) D_l - Dose to lens of the eye MPD 5 rem/yr.

(4) D_p - Penetrating dose MPD 5 rem/hr.

There were no significant neutron exposures and routine urinalyses gave no indication of significant internal exposures.

J. A. Cox

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JAC:gc

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X-847

INTRA-LABORATORY CORRESPONDENCE

OAK RIDGE NATIONAL LABORATORY

November 23, 1960

To: M. E. Ramsey, D. C. Hamilton, A. M. Perry, F. W. Manning, R. H. Ritchie, E. P. Epler, E. O. Wollan, F. Kertesz

Subject: Information for Review of Graphite Reactor Operation

From: J. A. Cox, Prepared from Reports by W. R. Casto, C. B. Gaither, L. E. Stanford, F. T. Binford, A. E. G. Bates, and H. V. Heacker

Except for the graphite annealing and the decontamination following the November 20, 1959, incident, the Graphite Reactor operation has been quite routine. These unusual jobs have, however, required considerable shutdown time. No radiation exposures or other radiation incident occurred except for the Pu contamination.

Annealing

The Graphite Reactor annealing operation was successfully performed during the period September 2 to September 4, 1960. The operation proceeded as planned with the exception of minor changes in the procedure as dictated by the existing conditions. During the operation it was demonstrated that with the high coolant flow rate (60,000 cfm) temperature rises due to the release of stored energy could be controlled by merely reducing the reactor power. It was further demonstrated that the release could be reinitiated by increasing the reactor power and reheating the graphite to the previous temperature. The ability to control the stored energy release and to resume the annealing at any later time proved to be an important advantage of this system.

The effectiveness of the annealing is now being determined. Approximately 100 graphite cores have been removed from the reactor for post-annealing analyses. Data from these are in good agreement with the temperature data taken during the annealing. From these data it is estimated that approximately 3 Mw hours of stored energy were released and that the annealing was very complete in a region of approximately 16 feet in diameter. Stored energy in excess of the specific heat curve still exists in a peripheral band including the outer three fuel rows. The exact boundaries of this region have not yet been located but are under study. In view of the apparent difficulty in heating this outer region, an accidental release of the remaining stored energy appears incredible.

An attempt was made to use a heat balance in establishing the total stored energy released during the annealing. Because of poor resolution of the various power measuring devices, all that could be established was an upper limit of 8 Mwhr.

The annealing method consisted essentially of the following:

1. Reversing the direction of the coolant flow and establishing a coolant flow rate of approximately 60,000 cfm.
2. Bringing the reactor to critical.
3. Slowly increasing the reactor power to obtain the desired graphite temperature.
4. After attaining a maximum permissible fuel element temperature, allowing the reactor to soak at constant power.
5. Reducing the reactor power and coolant flow to broaden the temperature distribution.
6. Scramming the reactor and shutting off the coolant flow to further broaden the temperature distribution and to heat up the center core region.
7. Conclusion of the annealing by establishing coolant flow and allowing the graphite to cool with the reactor shut down.

The front face water spray system proved adequate to control the front shield temperature below the previously established maximum of 100°C. Without the water spray the annealing could not have been performed without seriously endangering the front face shield.

Readings from the many radioactivity monitors employed during the annealing indicated lower than normal radioactivity release. This was due in large part to a very careful fuel inspection and removal of any doubtful elements prior to the annealing.

Numerous temperatures were recorded during the annealing operation. The recorded temperatures indicated the inception of stored energy release and gave an idea of the magnitude of the release. A time-temperature trace for channel 1969 is shown in Figure 1. The traces for three thermocouple locations in the channel are shown. A significant point in this trace is that the sharp rise in temperature occurred after the reactor was shut down. The annealing temperature was not reached in channel 1969 during the soaking period because of excessive coolant flow. Although the temperature in this center region would increase considerably due to conduction, the fact that the center temperature rose very rapidly to a value higher than any temperature in the surrounding region indicates a release of stored energy. Temperature profiles for channel 1969 at various times during the annealing are shown in Figure 2. Most of the other thermocouples showed similar time-temperature traces, but the greatest number of these occurred with the reactor operating.

An iso-temperature plot for a cut 97.5 inches from the east face at 9:10 a.m., September 4, is shown in Figure 3. Annealing of OGR graphite at 135°C will remove the stored energy in excess of the specific heat curve. Thus, the region inside the 140°C iso-temperature curve should now be relatively free of stored energy.

A complete evaluation of the annealing will be published.

Facility Utilization

Table 1 shows the present usage of the Graphite Reactor. It will be noted that usage by the Isotopes Division has declined to two positions used full time and three shared with others.

At the present time a Sandia Corporation experiment on radiation damage at low temperatures is being conducted in cooperation with the Solid State Division. Plans are under way for an Atomics International experiment lasting six months. Such experiments help pay for the cost of operating the reactor and reduce the cost to the Laboratory.

The Huntsville Arsenal has proposed a series of experiments in the OGR. The Laboratory representative involved discouraged the proposal since similar requests have been rejected in the past. However, if an unused facility could now be rented, a considerable portion of the reactor could probably be supported and the net cost to the Laboratory would be decreased.

TABLE 1. GRAPHITE REACTOR FACILITY EMPLOYMENT

Facility	Nature of Experiment	Division Sponsor
3		Operations
4	Service irradiation facility	Isotopes
10	Assigned for cryostat	Solid State
11		Operations
12	Cryostat	Solid State
13		Operations
14	Unit irradiation facility	Isotopes
15	Electronic component testing	Reactor (GE)
16	Graphite thermocouple (annealing)	Operations
17		Operations
18		Operations
19	Hydraulic sample tube	Solid State

Table 1. Continued

Facility	Nature of Experiment	Division Sponsor
20	Electronic component testing	Reactor (GE)
21		Operations
22	Pneumatic tube	Isotopes and Chemistry
30		Solid State
38-S		Operations
50-S	Neutron spectrometer	Physics
50-N	Cryostat	Solid State
51-S	Neutron spectrometer	Physics
51-N	Converter	Solid State
52-S	Neutron collimator	Physics
52-N	Cryostat	Solid State
54-N		Operations
55-N		Operations
56-N	Fast pneumatic tube	Chemistry
56-S	Oscillator	Reactor (GE)
57-N	Collimator	ORSORT
57-S		Operations
58-N		Operations
58-S	Neutron beam collimator	Chemistry
59-S		Operations
60	Electronic component testing	Reactor (GE)
61	Electronic component testing	Reactor (GE)
70		Operations
71	Water-cooled facility	Isotopes and Research
A, B, C, and D	Sample irradiation facilities	Operations
1867	Sample irradiation facility	Solid State
1768	Sample irradiation facility	Operations
1968	Sample irradiation facility	Operations
2568	Thermopile	Solid State
Core hole	Shielding facility	Neatron Physics
Thermal column	Shielding facility	Neutron Physics

Table 1. Continued

Facility	Nature of Experiment	Division Sponsor
East animal tunnel	Sample irradiation facility	Reactor (GE)
West animal tunnel	Sample irradiation facility	Isotopes and Chemical Technology
Slant animal tunnel		Research

Analysis of Unscheduled Shutdowns

TABLE 2. ANALYSIS OF UNSCHEDULED SHUTDOWNS

Classification	Number	Down Time (hr)
	Human Errors	
Operations	0	
Research	0	
Maintenance	2	0.783
	Equipment Failures	
Operations	27	68.985
Research	1	0.333
Total	30	70.101

Following are the details of the shutdowns.

1. There was only one shutdown due to real cause. The No. 3 cooling fan shut down when the run coil in the starter cubicle shorted. The reactor was scrammed due to loss of cooling.

2. Two shutdowns were caused by human errors.
   (a) An instrument engineer removed a line from a new installed reactor vacuum instrument thinking the device was not yet connected to the reactor safety circuit.
   (b) A maintenance supervisor actuated a scram switch which he thought was a light switch.

3. The 27 equipment failures charged to Operations were due to 7 fuel jacket failures, 6 power outages, and 14 scrams from instrument trouble, such as bad batteries and tubes.

Containment

No design for containment at the OGR has been developed as yet; however, the need is probably not as great as that at other facilities due to the type of experiments in the reactor.

Pu Contamination

The OGR was contaminated with Pu in the incident of November 20, 1959. Following decontamination of the main building on December 22, 1959, a crew of operators decontaminated laboratories and equipment until March 21, 1960. Approximately 90,000 square feet of surface area was decontaminated and 42,000 smear samples were counted. Most equipment was decontaminated in place, but some was removed for decontamination including a tape-type air monitor, four floor-type air conditioners, fifteen window-type air conditioners, two refrigerators and hundreds of pieces of scientific equipment. In total, approximately six truck loads of this type of material was decontaminated and returned to researchers or to storage. A pickup truck, seven aluminum shielding tanks used by the Lid Tank, and approximately ten large shields of polyethylene and lead were decontaminated at a temporary facility outside Building 3002.

The building and equipment were contaminated to as high as 15,000 d/m/100 cm^2, although large sections of the main building and most of the laboratories had very low levels of contamination.

The decontaminating group spent a total of 11,029 manhours on this work.

Radiation Incidents

No radiation incidents originated in the OGR area since the last review.

Personnel Exposure Through the Third Quarter of 1960

Listed below are the percentages of the MPD accumulated by all Operations personnel and the two assigned maintenance men who receive any appreciable exposure. Approximately 35 people are included.

	Average	High	Low
TSR_c	.8555 Rem 22%	1.425 Rem 36.5%	.120 Rem 3.1%
D_m	.99 Rem 12%	1.83 Rem 23%	.420 Rem 5.38%
D_1	.902 Rem 23.1%	1.63 Rem 41.9%	.34 Rem 8.7%
D_p	.902 Rem 23.1%	1.63 Rem 41.9%	.340 Rem 8.71%

Industrial Accident

On September 27, 1960, Sam Darr, an operator, was involved in an accident which resulted in a painful injury to the fourth finger of his right hand while working with the LITR single-place fuel carrier. This resulting in a lost time accident of five days.

This carrier had been redesigned so that it could be used for Chemical Technology shipments outside the Laboratory. In closing the rolling shield door of the carrier, Sam's hand became entangled in the guide mechanism of the door. Since the incident, the door handle has been changed so that the carrier is safer. More elaborate changes are under way to further increase the safety of the carrier.

Hole 22 P-Tube Replacement

The Oak Ridge Graphite Reactor pneumatic tube facility became contaminated with fission products when a sample capsule containing a few milligrams of uranium broke. Capsules removed from the tube at this time were so contaminated that they read 8 r/hr. The tubes inside the reactor were replaced and the section outside were decontaminated using Turco 4324 cleaning agent.

Fuel

The use of the hollow, eight-inch Savannah River slugs (called "dingot" slugs) has been continued. The use of these slugs saves a great deal of money since a special production of the four-inch slugs might be expected to cost $200,000 to $300,000. An average reactivity gain of 1.5 to 3.5 inhours per channel has been measured during substitution of the dingot for the old bonded slugs, and approximately 10% of the fuel is now of the new type. The new slugs were loaded as fuel ruptures occurred and as it became necessary to discharge fuel in order to sample the graphite for the annealing project. Figure 4 shows the present loading of the OGR.

During the first ten months of 1960, 27 slugs ruptured. There have been no ruptures of the Savannah River slugs.

All of the wood sections have been removed from the fuel channel shield plugs to forestall the possibility of a wood plug coming loose and stopping the air flow through the hollow center section of the new fuel elements. No detectable change in radiation at the front face could be measured. The exposed ends of the shield plugs read only 1.5 to 3.5 mr/hr at three inches with a G-M survey meter.

At the present time, the fuel inventory stands at 3573 Savannah River slugs. More can easily be obtained through the AEC.

Canal

Approximately 75% of the storage area in the canal, Building 3001, is now used for approximately 5,800 Snap I program slugs and 9923 bonded

Industrial Accident

On September 27, 1960, Sam Darr, an operator, was involved in an accident which resulted in a painful injury to the fourth finger of his right hand while working with the LITR single-place fuel carrier. This resulting in a lost time accident of five days.

This carrier had been redesigned so that it could be used for Chemical Technology shipments outside the Laboratory. In closing the rolling shield door of the carrier, Sam's hand became entangled in the guide mechanism of the door. Since the incident, the door handle has been changed so that the carrier is safer. More elaborate changes are under way to further increase the safety of the carrier.

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At the present time, the fuel inventory stands at 3573 Savannah River slugs. More can easily be obtained through the AEC.

Canal

Approximately 75% of the storage area in the canal, Building 3001, is now used for approximately 5,800 Snap I program slugs and 9923 bonded slugs discharged from the Graphite Reactor. Efforts are being made to send this material to a processing plant before the slug jackets fail.

Corrosion of the aluminum jackets in the canal proceeds at a fairly rapid rate. In a recent inspection of 600 Graphite Reactor slugs stored in the canal, 71 jackets were found to have failed. In some cases, the jacket was completely gone; and the slugs were 50% oxidized. Many of the slug jackets of the same group of 600 showed evidence of heavy aluminum corrosion.

Money for a capital work order for design and estimate of a system for filteration and demineralization of the canal water has been authorized. This system will keep the canal water clean and eliminate the need for discharging radioactive water into the process waste.

Since the beginning of a concerted effort in August to remove the sludge on the bottom of the canal, the activity in the water has decreased from approximately 1000 c/m/ml, as measured by scintillation counting, to less than 500 c/m/ml.

A work order has been issued for a small, 7 gpm, mixed-bed, automatic demineralizer for the canal in the OGR filter house. This equipment will eliminate an effluent of approximately 200,000 gal/month with a radioactivity of about 50 c/m/ml normally but up to 10,000 c/m/ml during filter changes.

During the years the usage of the canal has shifted. In the beginning, it was used exclusively for the OGR. At the present time, only part of canal costs can be fairly charged to the OGR. Large sections of the canal are now used by the ORR, the LITR, the Isotopes Division, and various research divisions.

Filter House

The filter house has operated without incident. On April 18, 1960, the Fiberglas filters in cell No. 4 were changed.

Filter efficiency checks showed that the filters operated normally. Gelman filter samples showed an average particulate concentration of 3.9×10^{-11} μc/cc of beta and 4.5×10^{-14} μc/cc of alpha in the air exhausted from the stack. This can be compared to tolerance which is 5×10^{-11} μc/cc for alpha and 1×10^{-1} μc/cc for beta. Radioactive gas was, of course, much higher due mainly to A^{41}.

Fan House

On June 28, 1960, the No. 3 fan motor caught fire while it was being started. It was replaced with one of the two spares. This spare motor was found to have excessive vibration, and a second spare motor was installed. Both of the faulty motors have been reconditioned by the K-25 shops and are ready for service.

The No. 2 fan developed a loud noise from vibration during its startup on August 31, 1960. Investigation disclosed that air flow turning vanes in the large elbow on the fan discharge duct had broken loose. New vanes were installed and those in No. 3 fan duct were inspected and repaired.

OGR Instrumentation and Control (Postannealing)

The changes made in the instruments and controls of the OGR in the last year were occasioned by the annealing operation. While the new instruments are not considered at all vital for normal operation, most of them have been kept in service and are expected to give information about the reactor which was not so readily and immediately obtainable in the past. Some of the new instruments operate on different principles from those of the regular control installation and may also provide information on their relative merits.

The flow of cooling air is normally monitored by instruments which look at the inlet-air duct flow with a pitot tube and at the pressure drop across the reactor itself by means of a differential pressure sensor. To these measurements a third has been added--the exit-air flow. The sensor here is a propeller driven, D.C. generator of the type used for wind velocity measurements in some weather stations. Each instrument is capable of scramming the reactor independently in case it detects a condition of undesirably low flow in the cooling system. It should be noted that no coincidence type of circuitry is used to prevent spurious scrams. Scrams are in the nuisance category rather than constituting a severe operating problem.

A direct scram capability has been added to the reactor exit, or "rear wall," vacuum monitoring system. For normal operation it has been considered quite adequate for this system to simply shut off the cooling air blowers if an overly high vacuum is detected; and, in turn, the reactor could be shut down through the flow instrumentation. The protection afforded is for the rear wall which would be subjected to undesirably high structural stresses under high vacuum conditions. Since temperature conditions during the annealing cycle are somewhat higher than during normal operation, the "head room" for temperature excursions is less. On this basis it seemed desirable, if not absolutely necessary, to call for a reduction in heat generation at the same time the cooling fans were to be shut down. As it now stands, high vacuum conditions simultaneously scram the reactor and shut off the cooling fans. In addition, a scram is now initiated by the two fan motor starters when both are shut off and these considered to be backed by the air flow instruments.

The temperature of one selected fuel element and one point in the graphite has customarily been monitored for abnormal conditions by instrumentation having both warning and scram functions. For annealing a relatively large number of additional fuel elements and points in the graphite were monitored. Part of the read-out was with multipoint recorders and these have been retained. As the system now stands, 25 fuel elements are temperature monitored by one or another of three recorders and 24 graphite temperatures by two others. All recorders have alarm and scram functions. The alarm-before-scram arrangement allows the operator time to take corrective action and, thus, possibly avoid the scram.

Several additions have been made to the means employed to monitor the condition of the cooling air after it leaves the reactor. Immediately after entering the exit duct the air is sampled and the particulates filtered from it are monitored for radioactivity. After passing through the exit-air filters and the blowers the air is again sampled for particulate activity, its gaseous component activity (absorption by activated charcoal trap), and its CO_2 content. The original, ion chamber monitor remains in service. All these monitors are arranged to warn the operator, but none have scram capabilities.

Exit- and inlet-air temperatures have long been measured near the reactor to provide data for heat-power calculations. A second exit-air temperature sensor has been added. This is located at the exit-air flow sensor, both of which are some distance downstream from the reactor. All are fed to the same multipoint recorder. No alarm or control functions are provided.

Preliminary Program for the Study of Irradiation of Thorium in the OGR

Because of the considerable interest of this Laboratory in the Th^{232}-U^{233} thermal breeding cycle, it has been suggested that the OGR might prove useful as a tool for the purpose of conducting some experiments to gain information with respect to this cycle. It seems reasonable to study the results obtained by loading some thorium slugs into the reactor in order to determine the conversion rates which can be expected. The ultimate aim would be to determine the feasibility of operating the OGR at least partially on thorium fuel.

In order to implement the plan, the following preliminary program will be carried out as time permits:

A. Theoretical

The effect of a partial loading of thorium in the OGR will be examined. This study would include the variation in time of reactivity as U^{233} is produced, together with the effects of various loading compositions.

The effect of mixing U^{235} and thorium in a single fuel element would also be examined.

B. Experimental

The results of the foregoing calculations will indicate the type of experiment most likely to produce useful results. The most obvious experiment will consist of a partial loading of thorium fuel and subsequent observation of the changes in reactivity due to the growth of U^{233}. It should be remarked that because of the low flux in the OGR, these experiments are likely to require a considerable time.

J. A. Cox (WRC)
J. A. Cox

JAC:gc

cc: F. R. Bruce
A. F. Rupp
A. M. Weinberg

Time - Temperature Trace for Channel 1969

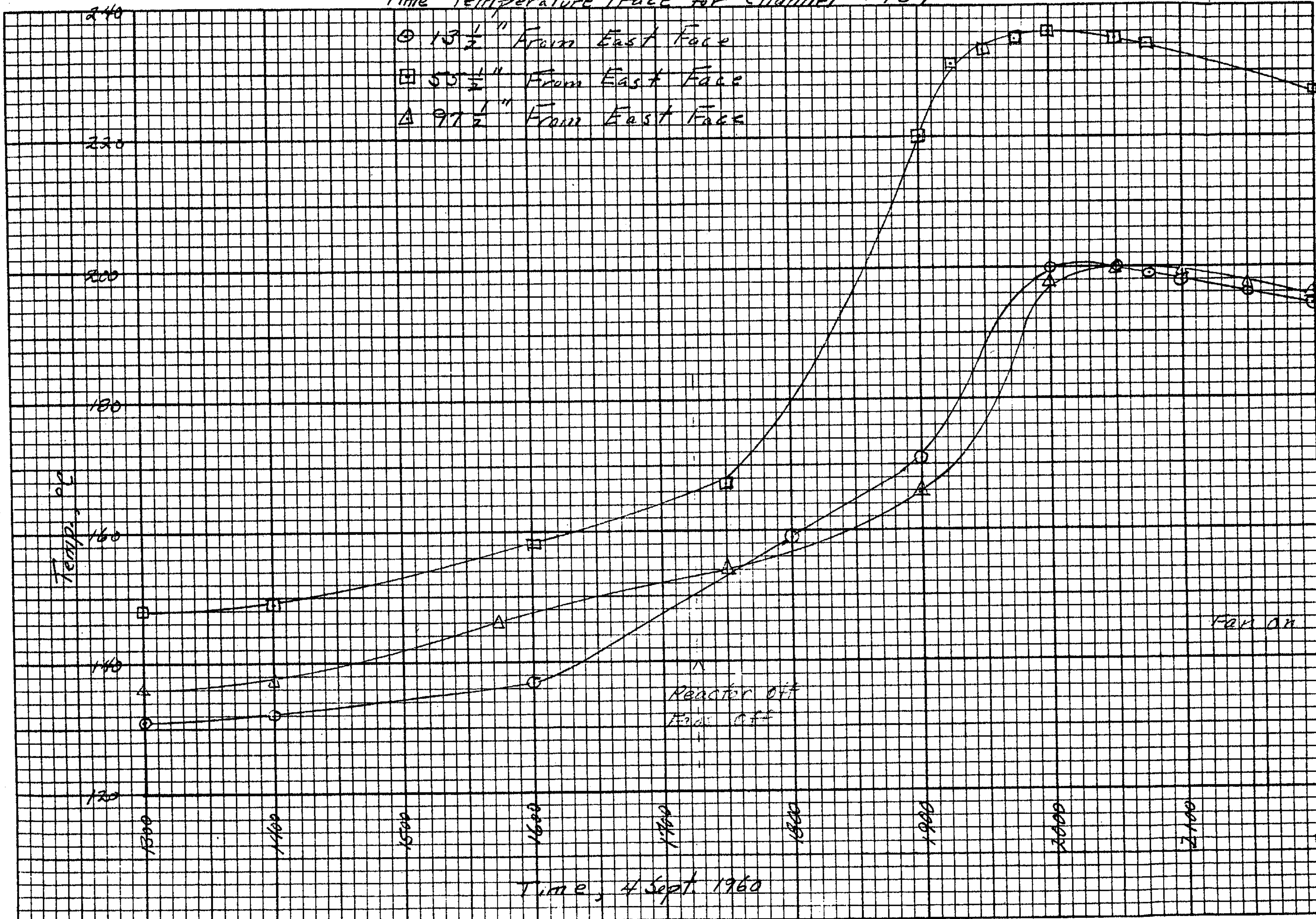


Fig 1

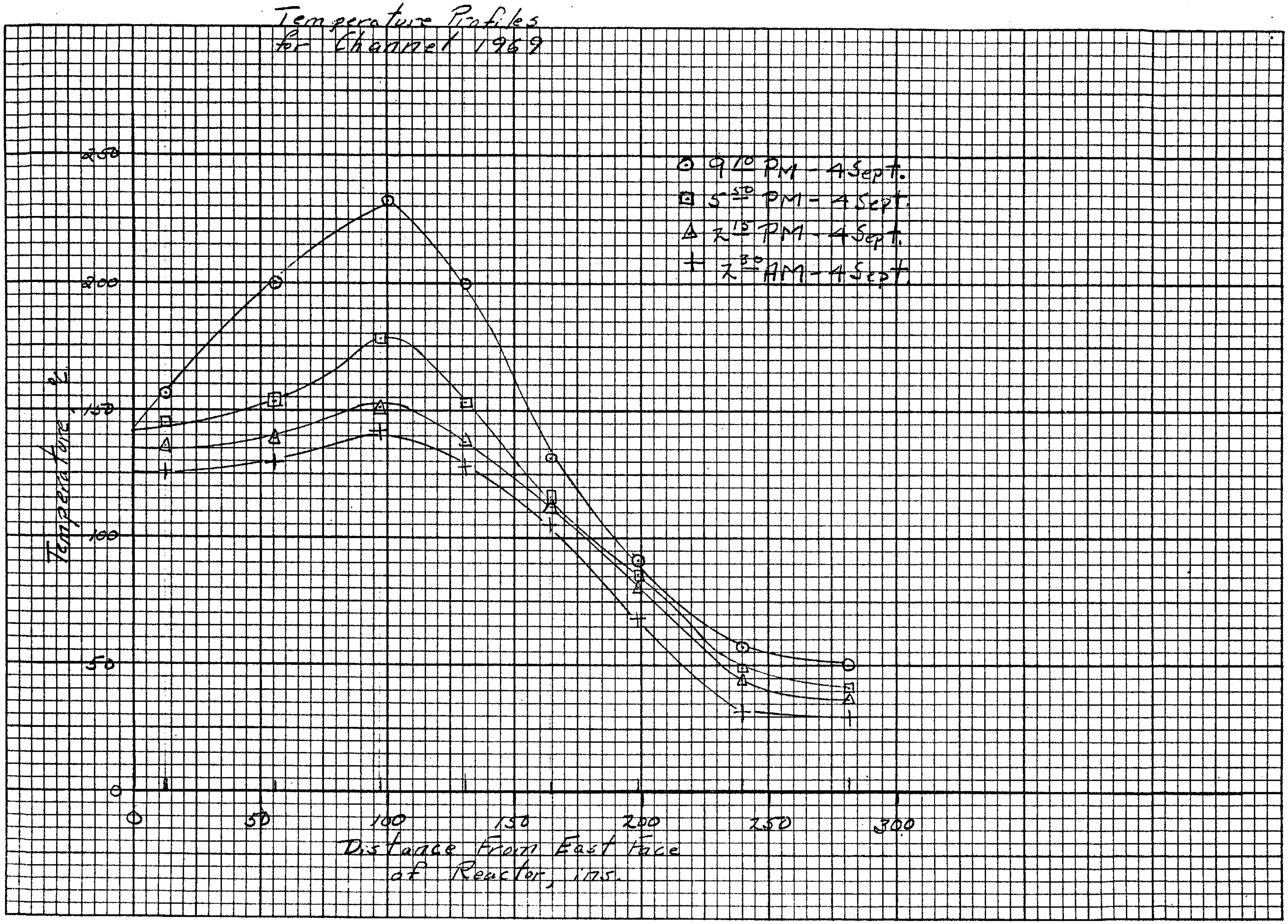

Temperature Profiles
for Channel 1969
9 10 PM - 4 Sept.
5 50 PM - 4 Sept.
2 15 PM - 4 Sept.
2 30 AM - 4 Sept.
Temperature, °C
250
200
150
100
50
0
0
50
100
150
200
250
300
Distance from East Face
of Reactor, ins.

Fig. 2.

OGR FUEL CHANNEL GRID

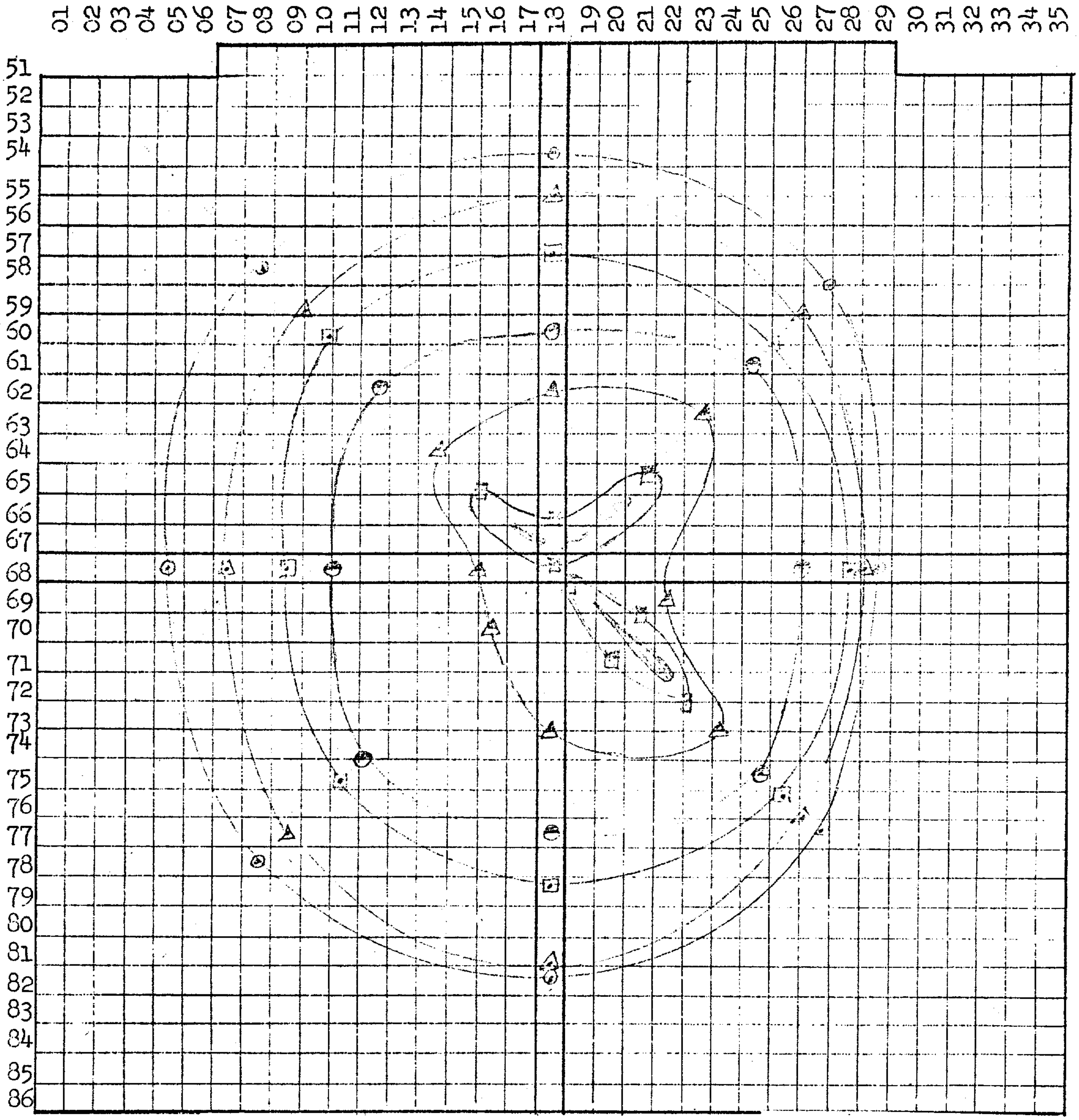


FIG. ...3

120°C
140°C
160°C
180°C
TX-2392 200°C
(8-18-60) 210°C
220°C

Iso. Temperature Plot 8'1½" From East Face of Graphite

9:10 PM on 4 Sept. 1960

All Fans Off - Reactor Off

UNCLASSIFIED
ORNL-LR-DWG 6755

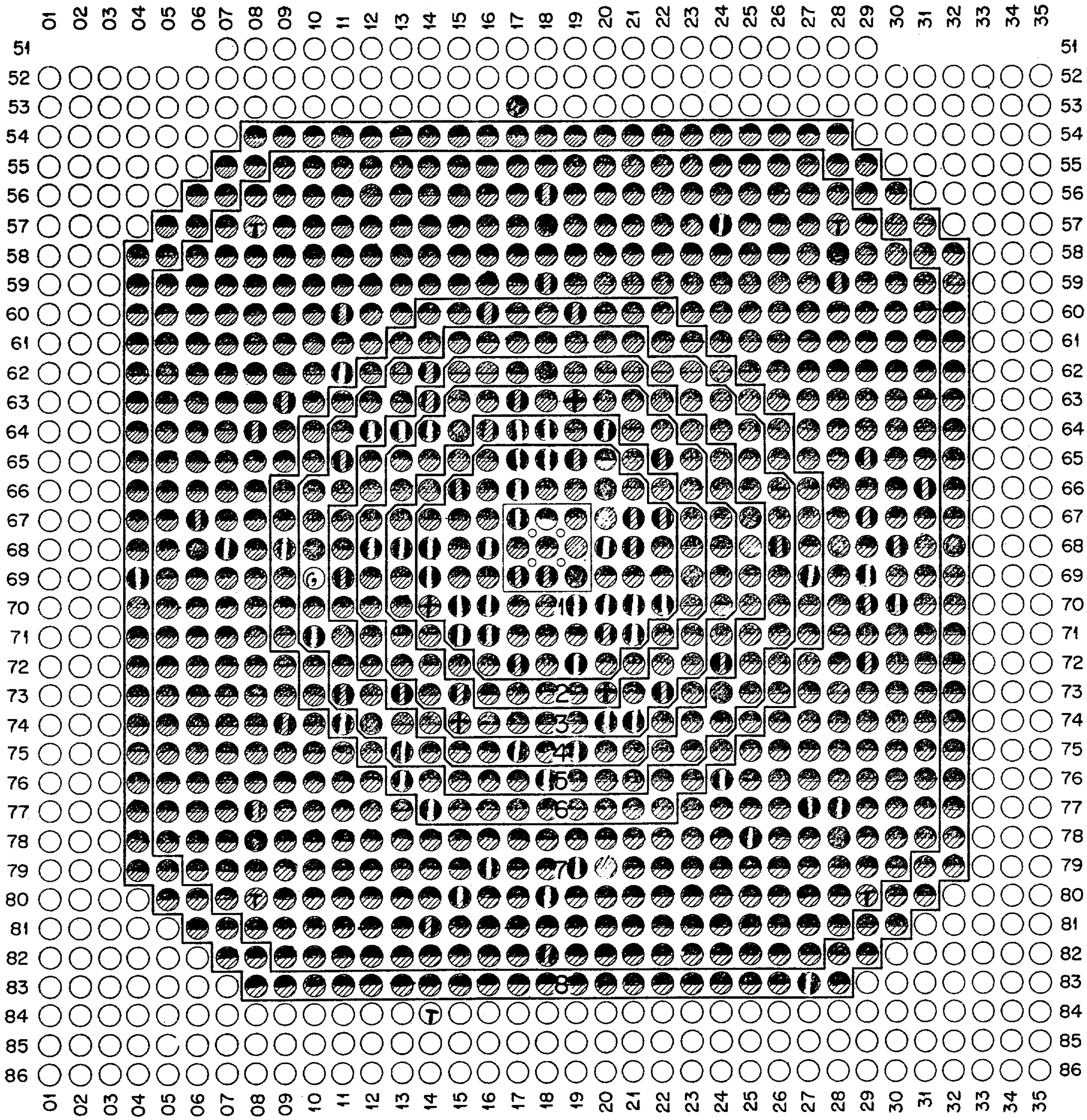


Fig. 4. OGR Fuel Loading Pattern

LEGEND

4" Bonded

8" Dingot

Graphite

8" S. R. U.

Thermopile

Gold

INTRA-LABORATORY CORRESPONDENCE

OAK RIDGE NATIONAL LABORATORY

November 7, 1961

To: M. E. Ramsey; D. C. Hamilton; S. H. Hanauer; F. W. Manning; A. M. Perry; R. H. Ritchie; F. Kertesz

Subject: Information for Review of ORNL Graphite Reactor Operation

Prepared by: C. D. Cagle, W. R. Casto, J. A. Cox, C. B. Gaither, L. E. Stanford, and M. C. Wittels

During the ten months beginning January 1, 1961, the Graphite Reactor has operated routinely with only 9.02% downtime. Even the annealing was almost routine because of previous experience. Unscheduled shutdowns have caused only 0.7% of the total downtime for the year to date.

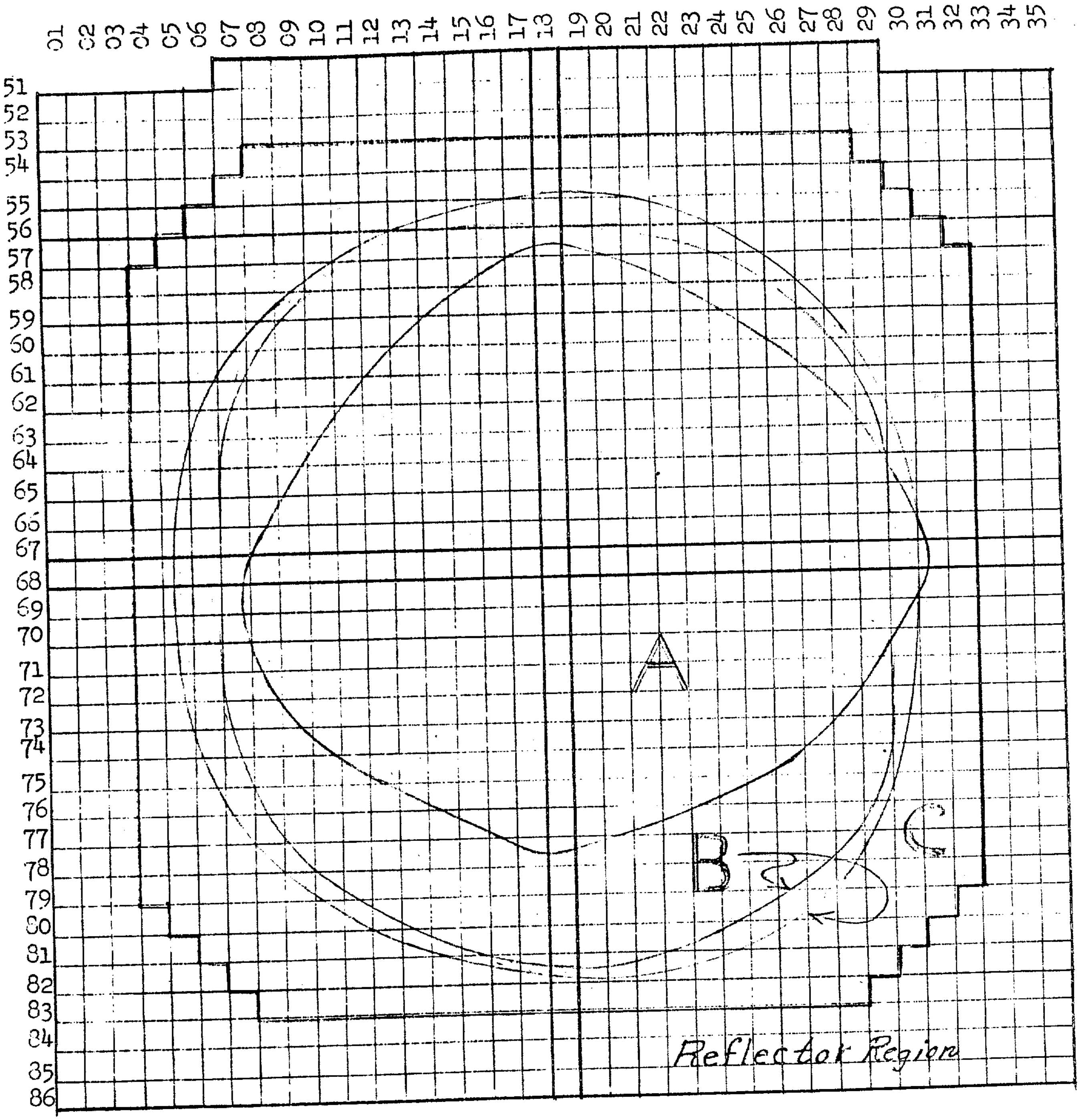
Annealing

A second phase of the Graphite Reactor annealing was performed during the period from 9-15-61 to 9-18-61. The operation proceeded without incident and, essentially, in accordance with the revised annealing procedure. An analysis of the present stored-energy condition is given in the attached discussion by M. C. Wittels.

The purpose of the 1961 annealing was to extend the region wherein effective annealing had been accomplished in the 1960 operation. Prior to the first annealing, temperature data and stored-energy analyses by X-ray techniques indicated that stored energy in excess of the specific-heat curve existed in a relatively small volume of the reactor moderator (shown approximately by area A in Figure 1). As reported last year following the first annealing, extensive stored-energy measurements showed that releasable stored energy existed in the peripheral regions of the reactor. It was found that spontaneously releasable stored energy exists even in the outermost fuel rows and that some stored energy (not spontaneously releasable) is present in the first reflector channels.

The area represented by region B in Figure 1 is enclosed by two 140°C isotherms. The inner curve was obtained during the 1960 annealing and thus encloses the region that was effectively annealed during that time. Area B represents the additional portion of the reactor that was effectively annealed during the 1961 operation. Essentially all of the central graphite in region C contains stored energy which could be released spontaneously; however, since this region could not be heated to 140°C even by the

OGR FUEL CHANNEL GRID



_____ Temperatures

TC Number _____

Inlet Temperature _____ °C

Exit Temperature _____ °C

Date 1961

Time _____

Reactor Power _____

Figure 1

contrived condition of the reverse-flow annealing, it appears very unlikely that a release would occur in normal operation.

In summarizing the present Graphite Reactor stored-energy condition, the following points appear important:

1. The reversed-flow, low-temperature method of annealing has permitted the release of all the 250°C-peak stored energy in a volume which well exceeds that for which it was planned.

2. An accidental release of the remaining stored energy has been shown to be highly improbable.

3. The existing annealing system, procedures, and operating limits for fuel temperatures, etc., do not provide sufficiently high graphite temperatures in the peripheral regions to accomplish the desired additional annealing. Therefore, revised procedures and supplementary devices such as orificing are being investigated. It is believed that a procedure can be developed to anneal the peripheral channels safely and economically.

4. The present theories of radiation damage and existing experimental data do not explain the amount of stored energy in the peripheral regions.

Facility Utilization

Table 1 shows the usage of the reactor. Since last year, usage has declined 20% largely because the General Electric group and the Isotopes Division released 10 facilities. A method of payment is now being used by the Isotopes Division whereby the reactor is credited with the income collected from customers.

Table 1. Graphite Reactor Facility Employment

Facility	Nature of Experiment	Division Sponsor
3		Empty
4		Empty
10	Assigned for cryostat	Solid State
11		Empty
12	Cryostat	Solid State
13	Sb-Be sources	Operations
14	Unit irradiation facility	Operations
15		Empty
16		Empty

Table 1. (Continued)

Facility	Nature of Experiment	Division Sponsor
17		Empty
18		Empty
19	Hydraulic tube	Solid State
20		Empty
21		Empty
22	Pneumatic tube	General Use
30		Solid State
38-S		Empty
50-S	Neutron spectrometer	Physics
50-N	Cryostat	Solid State
51-S	Neutron spectrometer	Physics
51-N	Cryostat	Solid State
52-S	Neutron collimator	Physics
52-N	Cryostat	Solid State
54-N		Empty
55-N		Empty
56-N	Fast pneumatic tube	Chemistry
56-S		Empty
57-N	Student training	ORSORT
57-S		Empty
58-N		Empty
58-S		Empty
59-N		Empty
59-S		Empty
60-S		Empty
61-S		Empty
71	Air-cooled irradiation facility	General use
A and B	Radiation damage	Atomics International
C	Radiation damage	Solid State
D	UC_2 and Th-U^{235} irradiations	Metallurgy

Table 1. (Continued)

Facility	Nature of Experiment	Division Sponsor
2568	Thermopile	Solid State
Core hole	Shielding facility	50% Neutron Physics
Thermal column	Shielding facility	25% Neutron Physics
East animal tunnel	Sample irradiation facility	General use
West animal tunnel	Sample irradiation facility	General use
Slant animal tunnel	Sample irradiation facility	General use

Analysis of Unscheduled Shutdowns

Table 2 shows an analysis of the unscheduled shutdowns occurring from January 1, through September 30, 1961.

Table 2. Analysis of Unscheduled Shutdowns

Classification	Number	Downtime (hrs)
	Human Error	
Operations	0	0
Research	0	0
Maintenance	2	1.433
Subtotal	2	1.433
	Equipment Failure	
Operations	6	3.016
Research	0	0
Maintenance	0	0
Subtotal	6	3.016
TOTAL	8	4.449

Only one of the eight shutdowns was due to a real cause. A solenoid valve on the air-control system for one of the two Hagen dampers on the main cooling fans failed. This caused the damper to close and therefore reduced the reactor air flow but not to the scram point. Before the fuel-element temperature reached the scram point of 290°C, the reactor was scrammed manually by the operator.

Human error was the cause of two shutdowns: (1) the reactor was scrammed by a power outage when a K-25 electrician made a mistake while checking breakers at the substation; and (2) an instrument mechanic disconnected a graphite-temperature thermocouple and caused the recorder to scram the reactor.

There was one scram due to a power outage during an electrical storm. The remaining four unscheduled scrams were due to reactor instrument difficulties.

Fuel

At the present time, approximately 25% of the core is charged with "dingot" slugs from the Savannah River Project. The first slugs of this type were loaded into the reactor in June, 1959, and are still in use. No slug-jacket failures have occurred in this fuel.

Slug-jacket failures in the old-type slugs totalled 16 during the first ten months of 1961. This is a smaller number than usual.

Requests have been made for 15,000 more "dingot" slugs. With the present inventory of 6,500, this will be sufficient to reload the reactor should this be desirable.

Reloading of the reactor with "dingot" slugs requires certain safeguards with respect to procedure and will, when completed, possibly require some rechecks of the operating characteristics of the reactor. Some considerations are:

1. During the reloading, there must be no mixing of the two types of slugs in the channels. Such mixing could block air flow through the hole in the "dingots" so that damage to the aluminum cladding could result.

2. The upper operating temperature of the metal has been set for the solid slugs; and, until these are all discharged, the present limit must not be raised. If it becomes necessary to use an instrumented "dingot" channel as the temperature safeguard channel, the maximum operating temperature limit should be lowered so that the maximum temperature of the old slugs does not exceed the present maximum since the "dingot" slugs operate cooler than the old ones.

3. The use of the hollow "dingot" slugs lowers the amount of U^{238} in the reactor seen by resonance-energy neutrons and may perceptably decrease the negative-temperature coefficient of the metal. This perhaps should be remeasured if as much as half the core is eventually charged with "dingot" slugs.

4. A total loading of "dingot" slugs plus orificing of the peripheral fuel channels will undoubtedly allow the power level to be increased, perhaps to greater than 4 Mw. This will be investigated.

It appears that a power increase and orificing will be desirable in order to diminish the rate of energy storage in the graphite. The better plugging of empty peripheral channels, which was done for the annealings, has forced more of the air through the core. Also the increased surface area of the hollow slugs allows more heat to be transferred directly to the air stream so that the graphite should become somewhat cooler unless the power level is increased.

Canal

The storage problem has been relieved by returning about 55% of the Savannah River fuel which had been stored for the Chemical Technology Division. A second carrier for enriched fuel elements has been procured and placed in service. This has reduced the inventory of depleted LITR and ORR elements to 25% of the peak number stored. There still are approximately 20 tons of bonded "X" slugs from the Graphite Reactor stored in the canal. Efforts are being made to send them to a processing plant.

During July, the Criticality Committee inspected the canal and found the fuel storage and handling methods to be safe.

In the near future the Ferguson Construction Company will start construction of a recirculating demineralization system and a recirculating filtration system.

Filter House

The filter house has operated without incident. On May 26, the absolute filters in No. 3 cell were changed.

Fan House

In March, an unusual sound was noticed when starting No. 2 fan. Inspection revealed that the fan rotor was rubbing the housing. It was decided to move the rotor by moving its bearing. Subsequent monthly inspections of the clearance on both fans have revealed no further changes.

Instrumentation and Controls

There have been no changes in the reactor controls since the last meeting. However, a good maintenance program has reduced instrument-caused scrams from 14 last year to 4 this year.

Radiation Incident

The reactor was shut down at 6:35 a.m., on February 3, 1961, for the removal of four tetrabromobutane samples from Hole 14, stringer B, positions 1, 2, 3, and 4. The normal 30-minute decay time was allowed before the shielding was removed and the stringer pulled. Normal procautions such as adequate negative air flow, use of vacuum cleaner attached to the No. 1

stringer shield, and contamination zone requirements were used.

Three samples were removed from the stringer and placed in the provided carriers. The fourth sample was placed in the isotope safe on the second level, south. The readings on the samples were 2 r/hr at 4 feet unshielded and 900 mr/hr through the carriers. The second sample removed, which contained 10.0122 gm of tetrabromobutane, gave off a slight vapor cloud when placed in the carrier. This vapor apparently contaminated the carrier and the immediate floor area to values of 2,000 c/m to 20 mr/hr β, γ. The contamination was confined to the pre-established contamination zone, and the carriers containing the samples were sent to the decontamination area for cleaning. The south second-level floor area was decontaminated without difficulty.

Two men received up to 50 c/m nostril contamination.

<u>Reactor Shield Studies</u>

The Neutron Physics Division has recently completed a study of radiation leakage from the reactor shielding as a preliminary exercise for evaluating the shield for the N.M.S. Savannah. The data has not been analyzed as yet. The only regions of above-tolerance radiation leakage found were those generally already known and either guarded or known to be essentially inaccessible. These were: around some of the beam holes, at the mattress-plate anchor penetrations, and the floor area immediately above where the inlet-air duct enters the reactor shield. The maximum leakages found were about 40 mr/hr.

J. A. Cox

J. A. Cox

JAC:gc

Attachment

cc: F. R. Bruce
S. J. Ditto
A. F. Rupp
J. T. Thomas
A. M. Weinberg

TO: Distribution

SUBJECT: 1961 Post-Annealing Stored Energy in the OGR

Introduction: Following the September, 1961, annealing of the OGR, graphite cores were taken from the three main areas of interest in the stack and stored energies measured by the radiation-calorimetric technique. The selection of these areas was pre-determined by the 1960 discoveries of stored energy in the extreme fuel corners and in the first reflector rows as well as by the peak temperatures reached during the 1961 anneal.

Results: The measured graphite stored energies are given in Table I and are largely self-explanatory. The stored energy distribution along the channels has been plotted in Fig. 1, but it should be borne in mind that the energies released as graphically shown were measured to different temperatures (Table I) and are therefore not strictly comparable; nevertheless, they are meaningful. Figure 2 shows the 140°C isotherm reached during the 1961 anneal 7' 6" west of the east graphite face, the inner periphery of the stored energy region in this plane determined in 1960, and the channels selected for stored energy measurements. The stored energy in excess of the specific heat curve was annealed in the area inside this 140°C isotherm (shaded area, Fig. 2), and since the temperatures further toward the center of the core were appreciably higher (> 200°C) annealing in the central portions of course reduced the stored energy up to 250°C, there, to near zero. (See 1960 Report.)

Discussion: It is clear from the stored energy measurements in the lateral fuel channels close to the 140°C isotherm (Fig. 2) that the spontaneously releasable stored energy in the lateral areas has been largely reduced so that the thickness of the areas is probably no greater than 12" and may even approach zero on the south and bottom sides of the fuel zone.

The accumulation of stored energy in the corner fuel channels continues to grow at about 2 - 2½ cal/gm/yr to 250°C, and at present is of a magnitude to cause an adiabatic rise, in those regions, to 350-375°C, if the stored energy is released under ideal adiabatic conditions. The volume of graphite in these regions is about 6 - 7% of the volume of the entire graphite stack, and therefore contains about 4.5 megawatt-hours of adiabatically releasable stored energy, at the present time.

As for the success of the annealing operations to date, the fact should not be overlooked that the stored energy region, which was the objective of the 1960 anneal, has been successfully annealed to a high degree. In addition it was again shown that it was virtually impossible to heat the corner regions to annealing temperatures even under the contrived conditions employed.

The growth of significant amounts of stored energy in the extreme corners of the fuel zone, even out to the very last slug rows, are still not adequately understood. For many winter months the temperature in these channels is considerably lower than 30°C; and, presumably, the damage rate at 10°C might be as much as 3 times greater than at 30°C, the lowest temperature at which important amounts of data are available. Nevertheless, the fast neutron flux >1 Mev is probably below an order of magnitude lower than that required by the accepted radiation damage theory to account for the damage produced. It therefore seems probable that present radiation damage theory is inadequate in this regard. As a matter of speculation it is felt that some of the stored energy problems in other air-cooled graphite reactors (e.g., Windscale, B.E.P.O., and BR-1) could be or have been due to stored energy accumulations at the extreme edges of the fuel zone where it previously could have been easily overlooked.

Now that air-flow in the reflector channels of the OGR have been blocked the entire fuel zone operates at a considerably lower temperature and stored energy will therefore accumulate at a somewhat higher rate in the reactor in the future. This, together with the present condition of the corner regions, the lateral regions, and the central region should be considered in determining future operating conditions.

M. C. Wittels
Solid State Division

TABLE I

Stored Energy Data - October, 1961

Corner Fuel Channels

Channel	Ft. from E. Edge	cal/gm	Max. Temp. °C
2980	3	17.2	242
2980	6	40.7	290
2980	10	45.4	296
2980	14	33.9	268
2957	5	43.7	293
2957	9	58.6	315
2957	$11\frac{1}{2}$	54.7	309
0757	4	39.5	278
0757	7	56.9	316
0757	$11\frac{1}{2}$	50.4	301
0780	3	16.8	244
0780	6	59.8	296
0780	9	41.4	287

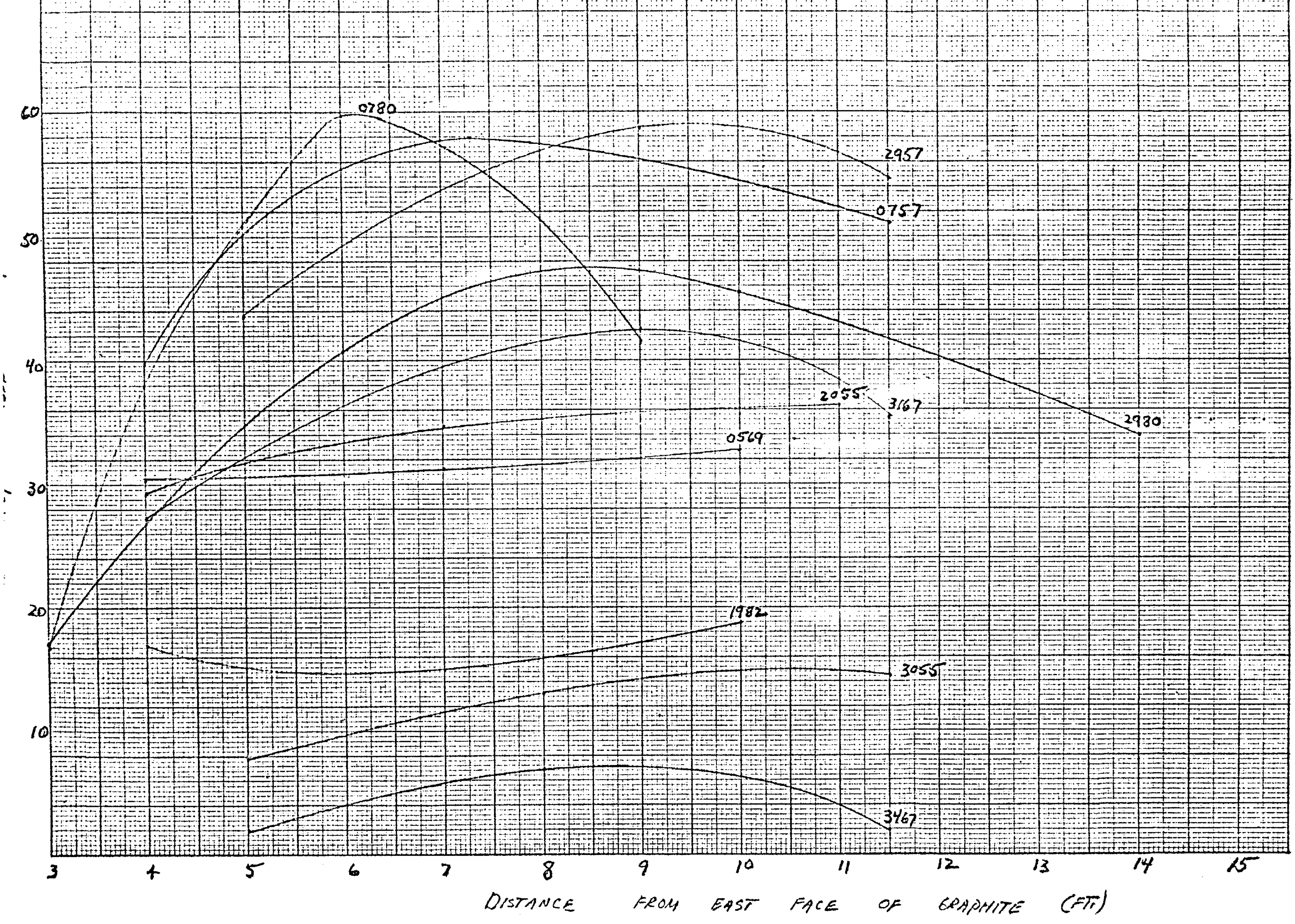
Lateral Fuel Channels

Channel	Ft. from E. Edge	cal/gm	Max. Temp. °C
3167	4	27.4	256
3167	9	42.4	262
3167	$11\frac{1}{2}$	35.6	256
2055	4	31.3	279
2055	7	34.7	273
2055	11	36.3	273
0569	4	30.4	266
0569	7	31.4	267
0569	10	32.7	269
1982	4	16.9	249
1982	7	14.9	247
1982	10	18.9	250

Reflector Channels

Channel	Ft. from E. Edge	cal/gm	Max. Temp. °C
3467	5	2	237
3467	8	7.0	239
3467	$11\frac{1}{2}$	2	237
3567	5	0	237
3567	8	0	237
3567	$11\frac{1}{2}$	0	237
3055	5	7.9	237
3055	8	13.0	238
3055	$11\frac{1}{2}$	14.4	238
3255	5	0	237
3255	8	0	237
3255	$11\frac{1}{2}$	0	237
3453	5	0	237
3453	8	0	237
3453	$11\frac{1}{2}$	0	237

FIG. I



0780
2957
0757
2055
3167
2980
0569
1982
3055
3467
60
50
40
30
20
10
3
4
5
6
7
8
9
10
11
12
13
14
15
DISTANCE FROM EAST FACE OF GRAPHITE (FT)

OGR FUEL CHANNEL GRID

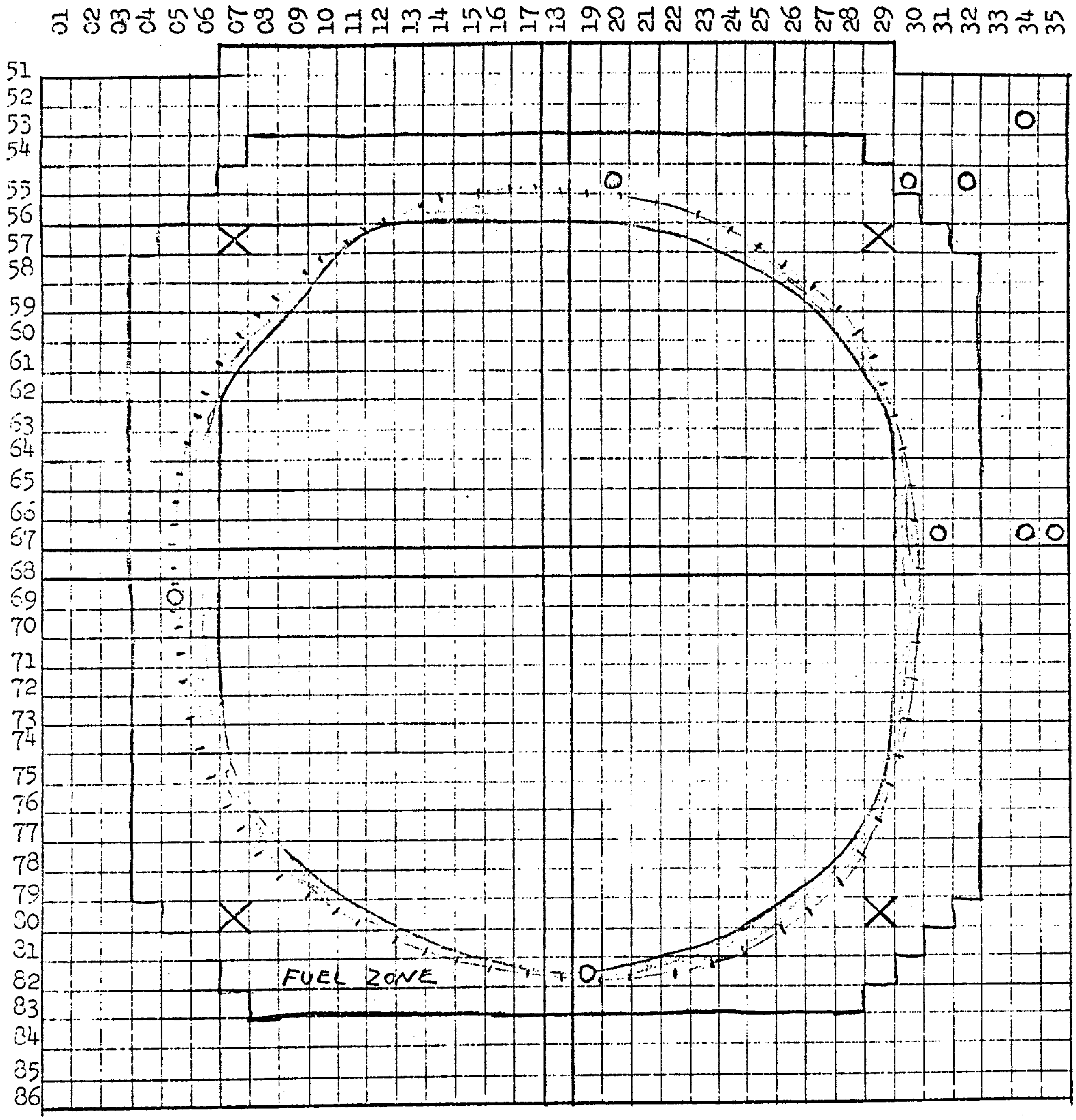


FIG. 2

_______ Temperatures

TC Number _______

Inlet Temperature _______ °C

Exit Temperature _______ °C

Date _______

Time _______

Reactor Power _______

140°C isotherm, 7'-6" from E. graphite face

inner periphery 1960 stored energy zone

apparent 1961 annealed regions

X corner fuel zone cores

lateral " " cores

o reflector zone cores

TX-2392
(8-18-60)